(54) Title: NETWORK ADDRESSING BASED ON PHYSICAL SITE LOCATION OF A NETWORK DEVICE

(57) Abstract: A method of network addressing based on the physical location of the devices in a network communications system. Accordingly, each the devices in the network communiations system is equipped with a physical site locator to identify the physical location of the device so that the physical location can be used as an address to allow the device to communicate with other devices in the network. Preferably, a mapping method is used to convert a map of physical locations to one or more address tables so as to allow a controlling station to route messages to and from the devices based on the physical locations. In a network where each network device has an intended function controlled by an application program, it is preferable that the application program is loaded onto the device after the physical location of the device is identified.

NETWORK ADDRESSING BASED ON PHYSICAL SITE LOCATION OF A NETWORK DEVICE

Field of the Invention

The present invention relates generally to a method for communication among a plurality of devices in a communications network. In particular, it relates to establishing the address for each device.

Background of the Invention

A local area network system, such as the Ethernet, can be used for industrial control applications. Such a network system can be used to enable programmable controllers, host computers, control devices such as adjustable frequency drives, and other devices to communicate through the production areas of an industrial plant. The devices connected together in such a communication link are generally referred to as "nodes". Each node has a unique Media Access Control (MAC) address as an identifier of the node to allow messages from one node to be sent to another.

In an automation factory where a plurality of automation devices are used to perform a variety of intended functions, each automation device has a controller, such as a programmable logic controller (PLC), to communicate with a controlling workstation or the PLC of another automation device. Furthermore, the PLC includes a software program to control the automation device in performing the intended function. It is quite common that the automation devices are placed at physical site locations in accordance with their particular functions. Conventionally, each of the automation devices is identified by the MAC address (or an Internet Protocol (IP) address) given to the PLC of the automation device. The MAC address is a fixed address which is given to an Ethernet module of a PLC when it is manufactured or assigned by a user, and the MAC address is unrelated to the physical site location of the device. If the PLC at one location is replaced by another PLC, the device at that particular location will not operate until the new MAC address of

addressing method is disadvantageous in a factory automation setting. If a problem develops with the device, maintenance must be performed by a professional who is skilled in networking management in order to associate the new MAC address with the old MAC address. This method is costly and can be time consuming.

It is, therefore, advantageous and desirable to provide a method and a network system wherein the need for the network management professional to be available for replacement of the factory device can be eliminated.

Summary of the Invention

One aspect of the present invention is a method of network addressing based on the physical site location of the network devices. The method includes the steps of identifying the physical site location of a network device and associating the physical site location to the device address so as to allow the device to communicate with other devices in the network.

Another aspect of the present invention is a network communications system having a plurality of devices, wherein one or more devices include means for identifying the physical location so that the physical location is used as an address of the device in order to allow the device to communicate with other devices in the communication system. Preferably, a software program is used to convert a map of physical locations of the devices into an address table required for routing messages to these devices.

Accordingly, a further aspect of the present invention is a device to be used in a network communications system wherein the device includes means for identifying its own physical location so that the physical location can be used as an address of the device in order to allow the device to communicate with other devices in the network communications system.

The present invention will become apparent upon reading the descriptions taken in conjunction with Figures 1-4.

Brief Description of the Drawings

Figure 1 is a block diagram showing a network communications system.

Figure 2 is a block diagram showing a network device.

Figure 3 is a block diagram showing a network communications system wherein a plurality of network devices share one physical location.

Figure 4 is a block diagram showing a mapping method for relating a physical location to the address of a network device.

Detailed Description of the Invention

The network communications system of the present invention is shown in Figure 1. As shown, the communications system 10 includes a plurality of network devices 101-105. Each of the network devices 101-105 is placed at one of the different physical locations 201-205, connected by a communication link 20. As shown in Figure 2, each device has a controller such as a programmable logic controller (PLC) 116 for controlling the device in carrying out the intended function thereof. Preferably, the communications system 10 is a modified local area network (LAN) wherein the address of each device to be used for communication purposes is associated with the physical site location of the device, rather than a Media Access Control (MAC) or an Internet Protocol (IP) address that is usually given to a PLC or to an input device of a PLC system. The network communications system can be any wired or wireless network that uses electrical signals, optical signals or other form of message signals to convey messages between devices in the system. The network communications system can also include one or more wide area networks (WANs). One of the network devices 101-105 may be a workstation or a master module to oversee the overall operations of the network communications system.

Figure 2 shows the components in a typical network device 100, representative of the network devices 101-105 shown in Figure 1. As shown in Figure 2, the network device 100 includes an I/O interface 122 for exchange signals or data with a machine or a monitoring apparatus; a network interface 112 to exchange signals or data with other

network devices in a network communications system; a physical site locator 114 residing inside or outside the network interface 112 to identify the physical location of the network device 100; and a programmable logic PLC 116 to control the machine or monitoring apparatus to which the network device 100 is connected using an application program 120 stored in a memory unit 118. These components can communicate with each other and other network devices 100 through a bus in the backplane 124.

In a factory automation system where a variety of automation machines are organized into a network communications system, and each automation machine is controlled by a network device 100, each machine may have a particular function to perform. For example, one machine may perform a metal stamping function while another performs metal surface polishing in an assembly line environment. Thus, the network device 100 connected to each automation machine includes an application program 120 to control the machine. In order for the machine to carry out the intended function in a timely manner, the network device 100 must have the ability to communicate with other network devices in the system.

It should be noted that, in some applications, the machines connected to a network are required to perform different functions. But in other applications, all machines can be used to perform the same function. For example, in a pipeline where batches of refined petroleum products are transported within a transport pipe from one state to another, a number of instruments are used at different locations along the pipeline to monitor the flow rate, fluid pressure and the content of the passing batch. Thus, all the monitoring instruments and the application program therefor can be identical. The only difference is the location of the monitoring instruments. In this type of the application, it is especially advantageous to use the physical site location as the address of each monitoring instrument.

In general, when the automation factory is designed, the industrial engineer works off of a floor plan. The floor plan is refined to an individual machine and to the physical site location of the machine. This physical location becomes the identifier of the unit or the address of the network device in the communications system. Once the automation machines are installed according to the floor plan, a software program is used to tie the

location on the floor plan to the location of the automation machine as identified by the physical site locator 114 of the network device 100 to which the automation machine is connected. Because the physical site locator 114 only recognizes the location of the machine and not the function of the machine, the network device 100 connected to one machine can be identical to the network device 100 connected to another machine. Thus, all network devices 101-105 as shown in Figure 1 can be identical. Once identified, all control or application programs and configuration information needed for an automation machine placed at a particular location to perform an assigned function can be downloaded from a master module, for example, to the PLC 116 of the network device 100. Preferably, a mapping software program is used to convert a map of the physical site locations of the network devices into one or more address tables required to route messages to these network devices. With such a mapping software program, the physical locator of a network device functions like the MAC address of the device regarding the routing of messages in a network. The mapping software will be described in conjunction with Figure 4.

If a problem develops with a network device 100 on a certain automation machine, that network device 100 can be replaced with another network device 100. Likewise, if a problem develops with a certain automation machine, it can be replaced with another similar machine, with or without changing the network device 100. Once the replacement is completed, the programs and configuration information can be downloaded again according to the physical site location as identified by the physical site locator of the replacement network device. Because the physical location of the automation machine remains the same, the programs and configuration information downloaded to control the automation machine will always be the same. Replacing a machine with a similar machine or replacing a network device on a machine does not require the skill of a professional in the field of network management. Thus, the maintenance of an automation factory can be greatly simplified and can be carried out in a cost-effective fashion.

As an additional benefit of the present invention, the location information in a hard wired factory can be used as a safety check to assure that the program in the PLC is intended to be operated at the location of the machine. It is not uncommon where a user

places the wrong PLC program into a PLC and the wrong PLC causes an unintended operation. By double-checking the physical location, most mistakes of this type can be eliminated.

The physical site locator 114 is known in the art. Personal locator technology, such as the Global Position System (GPS), a Time Difference Of Arrival (TDOA) device, or another Personal Locator System (PLS) can be used to identify the location of the network device 100 in which the physical site locator is included. However, each of these locator devices or systems has a location resolution beyond which the locator is unable to resolve. For example, a location resolution of 5 foot squared or better may be impractical in a factory automation setting where two or more machines are located closely together. In a different embodiment of the present invention as shown in Figure 3, one physical locator can be shared with a group of machines located in a small footprint. As shown in Figure 3, a network 10' comprises a group of network devices 101, 105, 106, 107 and 108, and a controlling workstation 119. While the devices 101 and 105 are separately positioned in physical locations 201 and 205, respectively, the devices 106-108 are located in the same physical location 206 to be associated with three machines. The shared physical locator is, for example, associated with one of the PLCs that controls the machines in the physical location 206. Thus, not all the network devices 106-108 have to use a physical site locator 114. However, the PLC 116 (see Figure 2) in each of the network devices 106-108 must have its own MAC address, IP address or another network address. When a PLC 116 is powered on, it learns its location from the shared physical locator and then transmits a message, providing both its MAC address and the shared physical location to the controlling workstation 109. A software program in the controlling workstation 109 would then translate this message in order to map the floor plan with the provided MAC addresses for the associated machines. As such, the controlling workstation 109 or another device can download an appropriate application program to the PLC, and the PLC would start with the application program intended for a network device in the shared location. It is possible that the message transmitted from a PLC 116 to the controlling workstation 109 is a Reverse Address Request Protocol (RARP) message.

Whether each network device 100 is positioned in a different physical site location as shown in Figure 1, or a number of network devices 100 share a physical site location as shown in Figure 3, it is advantageous to link a map of the physical locations to one or more address tables for routing messages to or from the network devices. Such a mapping method is shown in Figure 4. As shown in Figure 4, a map 300 having six different physical locations is related to an address table 310 having six different network addresses. For example, physical location 1 is associated with network address 1, etc. Depending on the communications network, the network address can be a MAC address, an IP address or another address type. The mapping between the physical location and the network address can be carried out by a software program in the master module, for example.

The method, the network device and the network communications system, according to the present invention, can be applied to a variety of monitoring programs. For example, a utility company can use the network device associated with a power meter to remotely read out the power meter at any location without the need of identifying the power meter. The network device can be programmed to automatically convey information including its physical location and the meter reading to the utility company according to the stored instruction. Similarly, a pipeline company can monitor the flow of the feed-stock at desired locations and time intervals. A water company can monitor water usage for billing and leak detection. A mining company can use a plurality of network devices, which can be moved to different locations if desired, to report the status of air quality or water levels. Network devices can be installed along with various monitoring instruments at various locations in a building to read out local temperature, humidity, air quality, lighting condition, etc. The present invention can also be applied to home automation in a smaller scale. Again, if a problem develops with a network device, any unskilled personnel can replace the network device.

Thus, the present invention has been described with respect to the preferred embodiments thereof. It will be understood by those skilled in the art that numerous changes and deviations in the form and detail thereof may be made without departing from the spirit and scope of the present invention. For example, the network communications system as depicted in Figure 1 can be replaced by a wireless network, or a network with a

plurality of gateways and bridges. Similarly, the device as depicted in Figure 2 can be
modified to include more components or to reduce the number of components. However,
these variations do not depart from the scope of the present invention wherein network
addressing is based, partly or completely, on the physical site location of the devices in the
network.

What is claimed is:

1.   A method of communicating with a device in a network communications system
wherein the device is positioned at a physical location, said method comprising the step of
identifying the physical location of the device so that the physical location can be used as
an address of the device in the network communications system.

2.   The method of claim 1, wherein the address of the device is a MAC address.

3.   The method of claim 1, wherein the address of the device is an IP address.

4.   The method of claim 1, further comprising the step of transmitting from the device
the physical location and the address thereof to a controlling station so as to allow the
controlling station to associate the physical location to the address for conveying signals to
the device.

5.   The method of claim 4, wherein the device has an intended function controlled by
a software program, said method further comprising the step of loading the software
program from the controlling station to the device after the physical location of the device
is identified.

6.   A method of communicating with a plurality of devices in a network
communications system wherein each device is positioned at a physical location, said
method comprising the step of converting a map of the physical locations of the devices
into one or more address tables, each table including a plurality of network addresses for
routing messages to the devices.

7.   The method of claim 6, wherein a controlling station is used to associate the
physical location to the network address of the respective device.

8. The method of claim 7, wherein each device comprises:

a programmable logic controller having a network address assigned thereto to communicate with the controlling station; and

a physical site locator to identify the physical location of the respective device.

9. The method of claim 7, wherein each device comprises:

an I/O device of a programmable logic controller system having a network address assigned thereto to communicate with the controlling station; and

a physical site locator to identify the physical location of the respective device.

10. The method of claim 6, wherein a software program is used to convert the map of the physical locations into the address tables.

11. A network communications system comprising a plurality of devices positioned at a plurality of physical locations, said system comprising means for identifying the physical locations of the devices so that each of the physical locations can be used as an address of a respective device in order to allow the devices to communicate with each other in the network communications system.

12. The network communications system of claim 11, further comprising means for converting a map of the physical locations into one or more address tables in order to route messages to the devices.

13. The network communications system of claim 11, further comprising a controlling station to receive messages containing the physical locations and associate the physical locations to the addresses of the devices.

14. The network communications system of claim 11, further comprising a local area network (LAN).

15. The network communications system of claim 11, further comprising a wide area network (WAN).

16. The network communications system of claim 11, further comprising a wireless access communications system.

17. The network communications system of claim 11, wherein each device has a unique physical location.

18. The network communications system of claim 11, wherein a plurality of devices share one of the physical locations.

19. The network communications system of claim 18, wherein each device has a MAC address and means for transmitting the MAC address and the shared physical location in a RARP message to a controlling station in order to establish the address of the device in the network communications system.

20. The network communications system of claim 18, wherein each device has an IP address and means for transmitting the IP address and the shared physical location in a RARP message to a controlling station in order to establish the address of the device in the network communications system.

21. A device located at a physical site in a network communications system comprising means for identifying the physical site location so that the physical site location can be used as an address for communicating with other devices in the communication system.

22. The device of claim 21, wherein the identifying means comprises a GPS site locator.

23. The device of claim 21, wherein the identifying means comprises a TDOA device.

24. The device of claim 21, further comprising means for storing a program in order to carry out an intended function.

25. The device of claim 21, wherein the network communications system is used to perform a plurality of tasks, said device further comprising means to convey signals to an apparatus connected to the device for performing a task.

26. The device of claim 25, wherein the network communications system comprises a controlling station to oversee the tasks and wherein the signal conveying means comprises a programmable logic controller to communicate with the controlling station.

27. The device of claim 25, further comprising means for storing a software program to carry out the task to be performed by the apparatus.
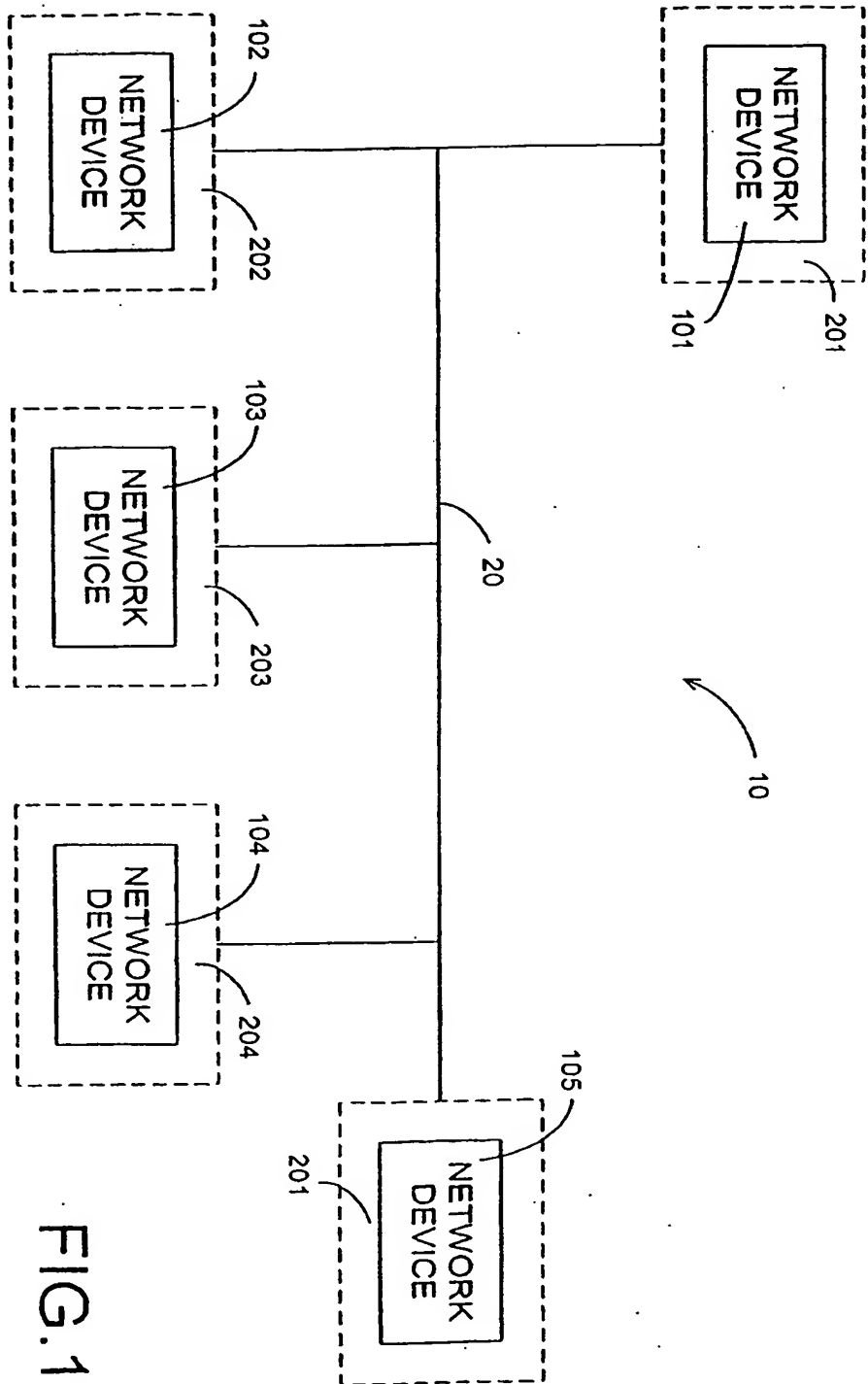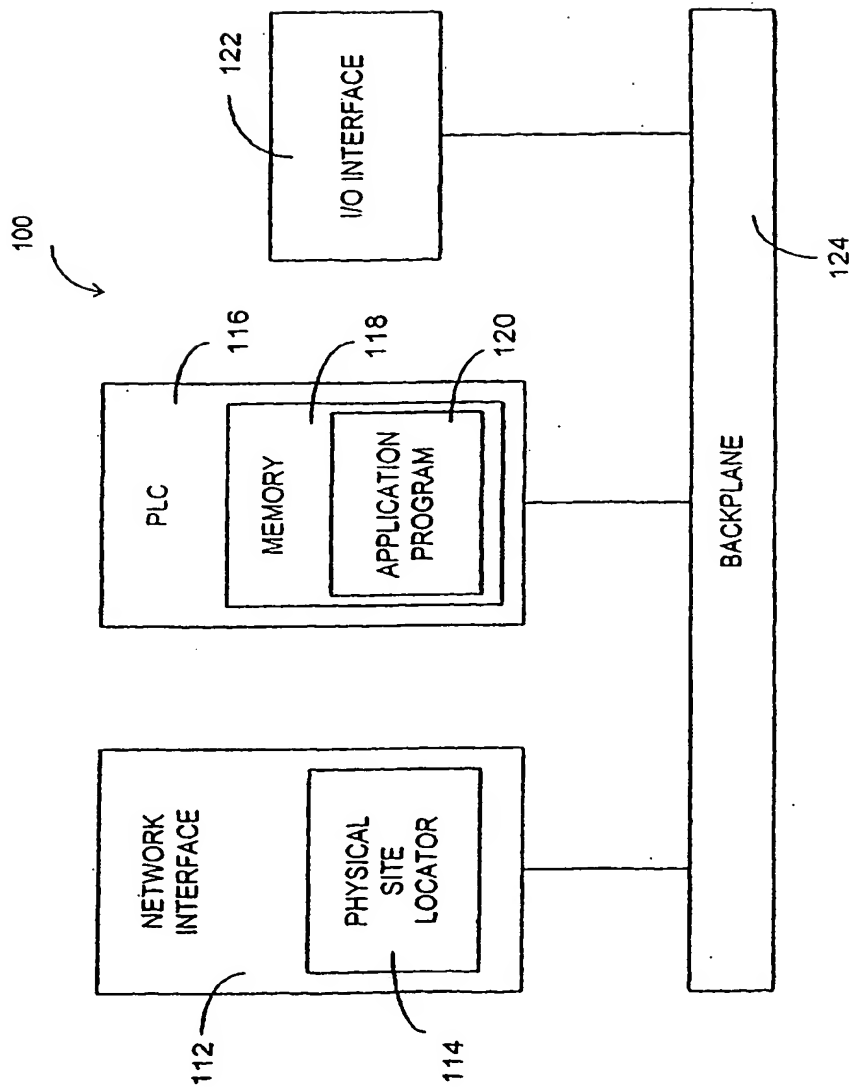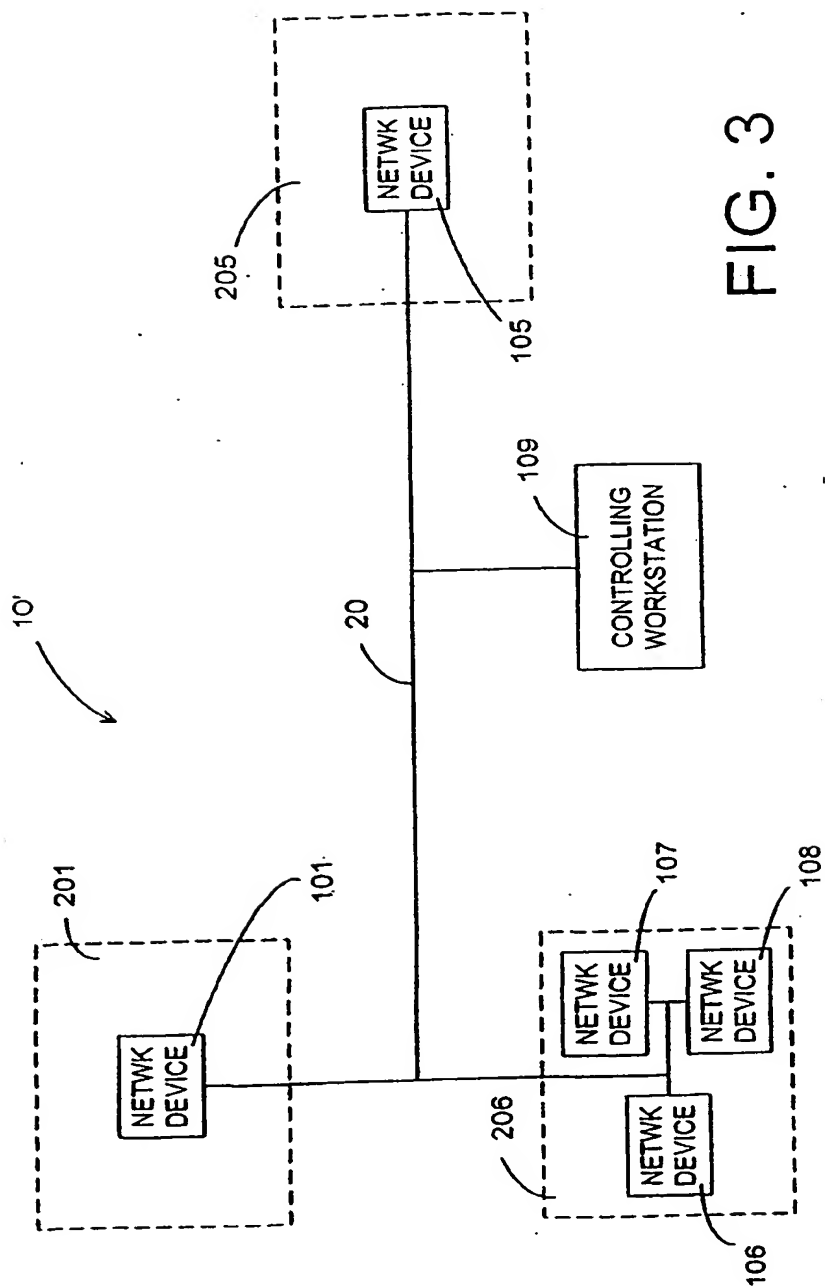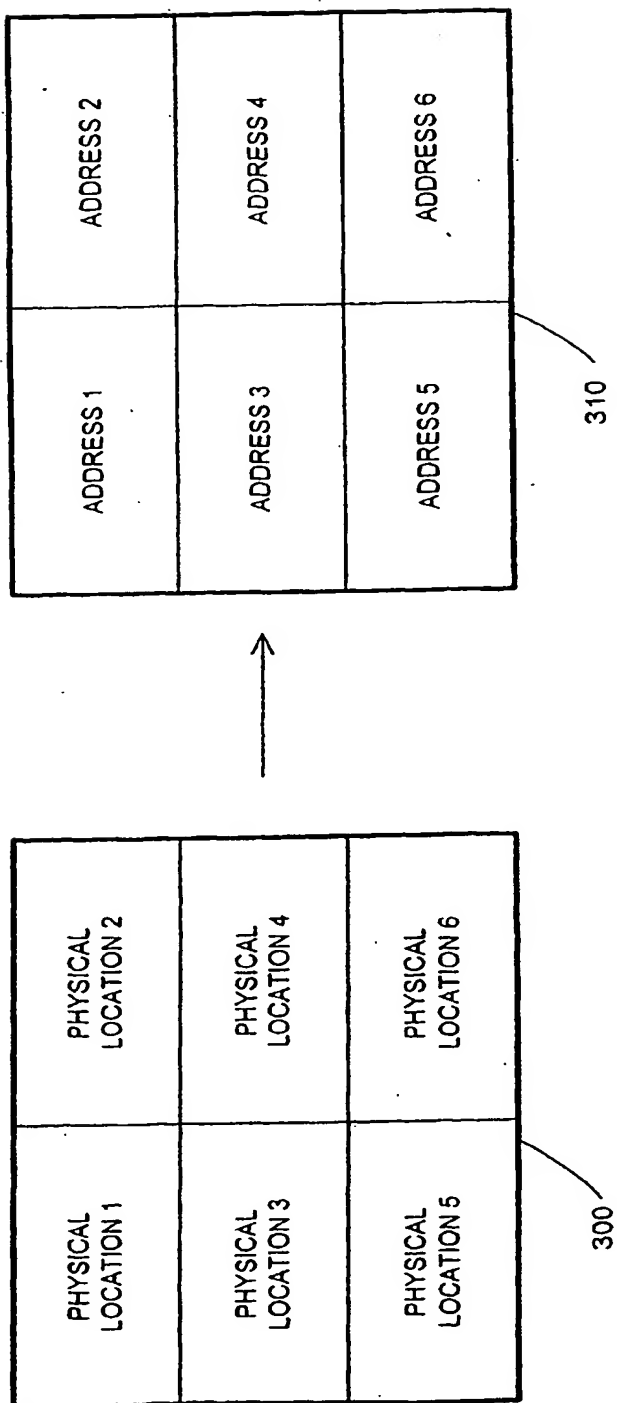
FIG.1

FIG. 2

FIG. 3

PHYSICAL LOCATION 1	PHYSICAL LOCATION 2
PHYSICAL LOCATION 3	PHYSICAL LOCATION 4
PHYSICAL LOCATION 5	PHYSICAL LOCATION 6

300

ADDRESS 1	ADDRESS 2
ADDRESS 3	ADDRESS 4
ADDRESS 5	ADDRESS 6

310

FIG. 4